

On the Growth Stages of *Conus fergusonii* Sowerby, 1873,
the Reinstatement of *Conus xanthicus* Dall, 1910,
and a New Species of *Conus* from the Galápagos Islands

BY

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(3 Plates; 4 Text figures)

INTRODUCTION

IN REVIEWS OF EASTERN PACIFIC *Conus* species, NYBAKKEN (1970: 25; 1971: 97) reported markedly different radula morphology between specimens considered adults and juveniles of *C. fergusonii* Sowerby, 1873. Nybakken suggested 3 possible explanations for this apparent anomaly: 1) dimorphism in *C. fergusonii*, 2) change in radula morphology with growth, 3) confusion between 2 species. Too few specimens were then available to allow resolution of the problem. Since that time additional specimens have enabled us to reach new conclusions.

Mature specimens of *Conus fergusonii*, largest of the tropical eastern Pacific species of *Conus*, have readily been recognized by previous workers. The juvenile shell of the species has not been understood, however. Recent authors (HANNA & STRONG, 1949; KEEN, 1958; EMERSON & OLD, 1962; HANNA, 1963; NYBAKKEN, 1970, 1971; KEEN, 1971) have considered the taxon *C. xanthicus* Dall, 1910, to represent the immature form of *C. fergusonii*. We now show that *C. xanthicus* is separable from *C. fergusonii* on both shell and radula morphology. The true juvenile of *C. fergusonii* is described and figured for the first time.

During this study, we found that some specimens from the Galápagos Islands thought to be *Conus xanthicus* had a radula unlike that of either *C. xanthicus* or *C. fergusonii*. We describe these specimens as a new species, *C. kohni* McLean & Nybakken.

In this account we give comparative descriptions of the 3 taxa and figure a number of specimens to illustrate growth stages and some of the variation in each species. We have examined all previously illustrated specimens in the California Academy of Sciences and the American Museum of Natural History collections. The figure citations in our synonymies are based upon new determinations of the identity of these specimens. Our radular descriptions employ the terminology used by NYBAKKEN (1970). The accounts of the radula are based on the following number of examined specimens: *Conus fergusonii* 5, *C. xanthicus* 10 (including the holotype); *C. kohni* 6 (including the holotype).

Museum abbreviations used in the text are as follows: AHF, Allan Hancock Foundation, University of Southern California (collection housed at LACM); CAS, California Academy of Sciences, San Francisco; LACM, Los Angeles County Museum of Natural History; USNM, United States National Museum of Natural History, Washington.

ACKNOWLEDGMENTS

We are especially grateful to Mr. Leroy H. Poorman, Westminster, California, who was much involved in the discussions that led to the recognition of the growth stages of these species. He has also donated specimens (Figures 6, 11, and 15) important to this work. Mr. Gerald Wellington, University of California, Santa Barbara, contributed specimens

from the Galápagos Islands, including the type lot of the new species. Additional specimens have been loaned by Mr. Alex Kerstitch of Tucson, Arizona. We thank curators and staff at the American Museum of Natural History, California Academy of Sciences, and the National Museum of Natural History for the loan of the specimens.

William K. Emerson, A. Myra Keen, Alan J. Kohn, Patrick I. LaFollette, and Leroy H. Poorman critically read the manuscript and offered helpful suggestions. We are grateful to Dr. Kohn for allowing us to compare the new species with his collection of type photography, specimens, and radula slides. The photographs are the work of Mr. Bertram C. Draper, Los Angeles.

SPECIES ACCOUNTS

Conus fergusonii Sowerby III, 1873

(Figures 1, 2, 5-11)

Conus fergusonii SOWERBY III, 1873: 145; pl. 15, fig. 1 - 1887: 256; pl. 508, fig. 675 - DALL, 1910: 218 - HANNA & STRONG, 1949: 294; pl. 7, fig. 3 - KEEN, 1958: 485; fig. 938 - EMERSON & OLD, 1962: 26; fig. 14 - HANNA, 1963: 42; pl. 4, fig. 2; pl. 9, fig. 10 - NYBAKKEN, 1970: 13; figs. 18, 19 (radula), figs. 40, 41 - NYBAKKEN, 1971: 97; fig. 4 - KEEN, 1971: 667; fig. 1511 left.

Diagnosis: Coronations persisting through 10th whorl, spire whorls slightly concave; large specimens white, small

specimens yellow-orange, with lighter, even banding; shells under 25 mm in length with widely spaced spiral rows of dark brown spots; spire lacking color pattern.

Description: Shell large (maximum length 153 mm, with 12 to 13 teleoconch whorls); spire low to moderately elevated; spire outline concave in small specimens to nearly straight in large specimens; shoulder sharply angulate in small specimens, less angulate in large specimens; the angulation with low coronations in small specimens, the coronations often persisting through a shell length of 50 mm; coronations indistinct and undulating in large specimens; spire whorls slightly concave, spire sculptured with fine spiral striae and growth lines; suture produced at the shoulder, deeply and narrowly incised; whorl profile more or less straight except convex below the shoulder; surface smooth except for 10-15 spiral striae on lower third of whorl; aperture moderately broad, of about the same width throughout and conforming to whorl profile. Protoconch homeostrophic, 3-whorled, smooth, dark; shoulder of early teleoconch whorls angulate; suture produced well below the angulation; suture rising to meet the shoulder by the 6th whorl; coronations on the shoulder angulation persisting to at least the 8-whorled stage. Color light yellow-orange, paler in medium-sized specimens, fading to white in large specimens; small specimens with a distinct lighter spiral band about the middle of the shell and usually a second light band at the shoulder; spire lacking color pattern; small specimens with spiral rows of dark brown dots on body whorl; aperture white within. Periostracum thin

Explanation of Figures 5 to 12

(Figures are scaled to render a shell 60 mm in length at life size and a 15 mm shell at a length of 35 mm, with intermediate-sized shells proportionally scaled. Spire views are oriented perpendicular to a plane touching the apex and the shoulder and are enlarged to a diameter of 2/3 the length of the frontal view.)

Conus fergusonii Sowerby III, 1873

Figure 5: AHF 395-35, 26-29 m, rocky, off Isla Lobos de Afuera, Peru. Radula verified specimen, length 61 mm, periostracum intact.

Figure 6: LACM 35506, 73 m, muddy, Bahía Bocochibampo, Guaymas, Sonora, Mexico. Length 52.6 mm, periostracum removed (spire with persistent coronations; largest specimen examined showing juvenile spotted pattern).

Figure 7: LACM 72-73, 40-55 m, Golfo Dulce, Puntarenas Prov., Costa Rica. Length 52.4 mm, periostracum intact (spire coronations relatively faint).

Figure 8: AHF 431-35, 82 m, sand & gravel, off Rocas Octavia, Colombia. Radula verified specimen, length 43.5 mm, periostracum intact (spire coronations prominent).

Figure 9: CAS 12310, 77 m, off Punta Judas, Costa Rica. Length 42.8 mm, periostracum removed from body, intact on spire (spotted specimen figured by HANNA, 1963, pl. 9, fig. 10).

Figure 10: LACM 72-12, 53-26 m, mud, Bahía Elena, Guanacaste Prov., Costa Rica. Radula verified specimen (see Figure 2), length 26.1 mm, periostracum removed (spotted juvenile; smallest radula-verified specimen).

Figure 11: LACM 36563, 20 m, Bahía Santiago, Colima, Mexico. Length 14.0 mm, dead specimen, periostracum worn away (spotted juvenile, smallest specimen examined).

Conus virgatus Reeve, 1849

Figure 12: CAS 39174, vicinity of Guaymas, Sonora, Mexico (from shrimp boats). Length 41 mm, periostracum removed, surface eroded (example of banded form; note lack of coronations; specimen previously misidentified as *C. fergusonii*).



Figure 5



Figure 6



Figure 7



Figure 8



Figure 9



Figure 10



Figure 11



Figure 12

and light colored in small specimens, thick and dark brown in large specimens, produced in closely set, concave ridges on the spire. Operculum bluntly unguiculate, about 4 times longer than wide.

Radula (Figures 1, 2): Tooth from mature specimens



Figure 1

Conus fergusonii, from 26.1 mm specimen (shell: Figure 10).
Radular tooth (scale = 0.1 mm)

(Figure 2) long; serration extending half the length of the tooth, terminating proximally in a pointed or rounded cusp; barbs 2, one at the tip, the other on the opposite side; blade and waist lacking, base enlarged, rounded, bearing a pointed spur. Tooth from the smallest specimen examined (Figure 1) (shell length 26.1 mm, Figure 10), proportionately shorter, the 1st barb weaker, 2nd barb undeveloped; waist indistinct, the proximal portion of the shaft wider than the distal; base enlarged, rounded, with prominent spur.

Radula preparations were made from 5 specimens, including those illustrated in Figures 5, 8, and 10. Except for the radula from the smallest specimen (Figure 10), there was no significant variation in tooth morphology.

Distribution and occurrence: Bahía Tortuga, Baja California, Mexico (HANNA & STRONG, 1949), north in the Gulf of California to Guaymas, Sonora, south to Isla Lobos de Afuera, Peru; Galápagos Islands, Ecuador. *Conus fergusonii* is uncommon at the Galápagos Islands; we have received specimens collected by Gerald Wellington at Isla Isabela and HANNA & STRONG (1949) mentioned a specimen of 128 mm in length collected at Caleta Tagus, Isla Isabela. Near the northern and southern range extremes, the entrance to Bahía Magdalena, Baja California, Mex-

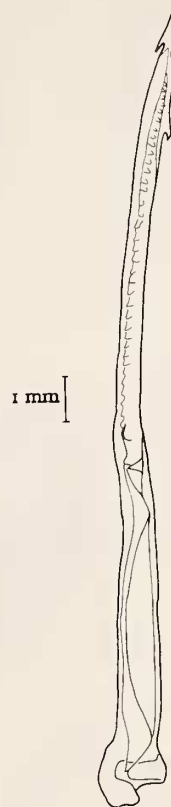


Figure 2

C. fergusonii, from 51.9 mm specimen (Gulf of Panama, Univ. of Miami, uncatalogued).

Radular tooth (scale = 0.1 mm)

ico, in the north, and Isla Lobos de Tierra and Isla Lobos de Afuera, Peru, in the south. McLean observed *C. fergusonii* on rocky bottoms at shallow subtidal depths. At localities in the central part of the range it is less common and is known only from dredged records. The species is not restricted to a rocky substrate; McLean has observed large numbers taken on soft bottoms on the shrimp fishing ground in the Gulf of Guayaquil off northernmost Peru.

Comparisons: Immature specimens of *Conus fergusonii* differ from *C. xanthicus* and *C. kohni* in having prominent coronations on the early whorls. The coronations persist through at least the 8-whorled stage and may be observed in spire view on specimens of any size, including shells with

intact periostraca. Similar persistent coronations characterize *C. patricius* Hinds, 1843, but that species differs in having a rounded shoulder and a marked concavity of the lower body whorl profile, features particularly apparent in young shells. The color patterns of young shells of *C. fergusoni* differ from those of both *C. xanthicus* and *C. kohni* in lacking mottling on the spire and in having even banding, and in younger stages, rows of dark spots, instead of mottled banding with jagged edges.

An uncommon color form of *Conus virgatus* Reeve, 1849, has also been a source of confusion. This form, an example of which was described as *C. signae* Bartsch, 1937, lacks axial flammules and may have a central band of lighter color intensity. However, such specimens of *C. virgatus* (Figure 12) lack coronations on the spire and the whorls are not as rapidly expanding as in *C. fergusoni*.

Variability: *Conus fergusoni* is moderately variable in shell proportion and height of spire. For example, shells in Figures 6 and 7 are of about the same length but that in Figure 6 is lower spired, broader at the shoulder and has a more pronounced bulge below the shoulder. Young shells lose the typical coloration of banding and spotting at different sizes. All of the 5 smallest shells examined (none exceeding 26 mm in length) are spotted. Spots have been observed on one shell as large as 52.6 mm in length (Figure 6); the smallest shell observed on which spots are lacking is 43.5 mm in length (Figure 8).

Remarks: The original illustration of *Conus fergusoni* is an accurate rendition of a large, white-shelled specimen lacking the periostracum, 145 mm in length, apparently life size, no dimensions being given. The description consisted of a brief Latin diagnosis. The source of the original material was given as follows: "Several specimens . . . collected at Panama by Mr. Ferguson." The present location of type material is unknown; specimens have not been located in the British Museum (Alan J. Kohn, personal communication).

Previous accounts of *Conus fergusoni* have included *C. xanthicus* Dall, 1919, as a synonym, thereby attributing excessive variability to the species. This confusion is no doubt due to scarcity of juvenile specimens of *C. fergusoni*. In all the museum and private collections examined by us, we have located only five specimens under 40 mm in length. McLean can attest to the apparent absence of juveniles, having seen numbers of mature specimens at Isla Lobos de Afuera, Peru, but none under 55 mm in length, despite having taken many gravel samples from crevices and under rocks.

HANNA & STRONG (1949: 295) and HANNA (1963: 43) claimed that "a magnificent series of growth stages has enabled us to state with assurance that *C. xanthicus* is the young of *C. fergusoni*." We have examined all small specimens in the California Academy collection previously identified as *C. fergusoni* and find that the smallest authentic specimen studied by Hanna is the 42.8 mm shell figured in

Explanation of Figures 13 to 23

Conus xanthicus Dall, 1910

- Figure 13: USNM 111236, Holotype of *C. xanthicus*, 130 m, sand, off Guaymas, Sonora, Mexico. Radula verified specimen, length 42.5 mm, periostracum removed.
- Figure 14: Berry Collection, Holotype of *C. chrysocestus*, 55-82 m, off Morro Colorado, Sonora, Mexico. Length 45.3 mm, periostracum removed (relatively low-spired specimen).
- Figure 15: LACM 11345, 73 m, off La Paz, Baja California, Mexico. Radula verified specimen, length 53.4 mm, periostracum removed (relatively low-spired specimen).
- Figure 16: AHF 1118-40, 108-126 m, coarse gray sand, Banco Gorda, Baja California, Mexico. Length 40.0 mm, periostracum removed on ventral side, intact on dorsal side (relatively high-spired specimen).
- Figure 17: CAS 17809, 29 m, Bahía Chamela, Jalisco, Mexico. Length 41.9 mm, periostracum intact (relatively low-spired specimen; spiral sculpture on spire whorls especially prominent).
- Figure 18: AHF 300-34, 73 m, sand, Bahía Azufre, Isla Clarion, Revillagigedo Islands, Mexico. Radula verified specimen, length 24.3 mm, periostracum removed.
- Figure 19: AHF 431-35, 82 m, sand & gravel, off Rocas Octavia, Colombia. Radula verified specimen, length 39.1 mm, periostracum removed (relatively slender specimen).
- Figure 20: AHF 325-35, 146 m, rocky, Caleta Tagus, Isla Isabela, Galápagos Islands, Ecuador. Length 46.8 mm, periostracum removed (largest specimen examined from Galápagos Islands).
- Figure 21: AHF 792-38, 128-146 m, off Isla Daphne Chica, Galápagos Islands, Ecuador. Radula verified specimen, length 35.7 mm, periostracum intact.
- Figure 22: CAS 38975, 18-37 m, off Isla Rabida, Galápagos Islands, Ecuador. Length 32.2 mm, periostracum removed.
- Figure 23: AHF 324-35, 82 m, rock, Caleta Tagus, Isla Isabela, Galápagos Islands, Ecuador. Radula verified specimen, length 14.3 mm, periostracum partially intact (smallest specimen examined).



Figure 13



Figure 14



Figure 15



Figure 16



Figure 17



Figure 18



Figure 19



Figure 20



Figure 21



Figure 22



Figure 23



color (HANNA, 1963: plt. 9, fig. 10), our Figure 9. Other small specimens in the Academy collection are identified by us as *C. xanthicus*. There is no indication of intergradation with *C. fergusonii*. EMERSON & OLD (1962: 27) considered specimens resembling *C. xanthicus* "to be merely a highly colored deep water ecotype of *C. fergusonii*," but did not document any depth-related distinctions. They noted coronations in the one authentic specimen of *C. fergusonii* they illustrated but did not question the lack of this character in the other specimens so identified.

Conus fergusonii is one of few species in which a young specimen of *Conus* has been shown to have a radular tooth morphology differing from that of the adult. We treat this further in the discussion section of this paper.

Conus xanthicus Dall, 1910

(Figures 3, 13-23)

Conus xanthicus DALL, 1910: 225 - HANNA & STRONG, 1949: 294 (as syn. of *C. fergusonii*), plt. 7, figs. 1, 2, 4 (holotype) - KEEN, 1958: 485 (as syn. of *C. fergusonii*) - EMERSON OLD, 1962: 26 (as syn. of *C. fergusonii*), figs. 13 left 13 right, 15 left, 15 right - HANNA, 1963: 42 (as syn. of *C. fergusonii*), plt. 2, fig. 4, plt. 5, fig. 5 (holotype), plt. 7, fig. 9 - NYBAKKEN, 1970: 25 (status uncertain); fig. 20 (radula), figs. 42, 43 - NYBAKKEN, 1971: 97 (as possibly valid species); fig. 5 - KEEN, 1971: 667 (as syn. of *C. fergusonii*); fig. 1511 right (holotype of *C. chrysocestus*).

Conus chrysocestus BERRY, 1968: 157 - NYBAKKEN, 1971: 99 (as syn. of *C. fergusonii*) - KEEN, 1971: 667 (as syn. of *C. fergusonii*); fig. 1511 right (holotype).

Diagnosis: Coronations present only at very early stage, spire whorls slightly concave, aperture narrow; color yellow-orange, lighter color bands irregular, mottled; spire whorls mottled; spire color darker than that of body whorl.

Description: Shell medium-sized (maximum length 54 mm, with 10 teleoconch whorls); spire varying from low to moderately elevated; spire outline straight to somewhat concave; shoulder distinctly ridged, not coronated in mature stages; spire whorls flat to slightly concave, spire sculptured with faint growth lines and microscopic spiral striae; suture produced below the shoulder ridge, well defined but not deeply channeled; anal sinus of medium depth; body whorl profile with a faint convexity below the shoulder, basal profile variable from straight to convex or concave; surface smooth except for 10-15 spiral striae on base; aperture relatively narrow, of same width throughout and conforming to whorl profile. Protoconch homeostrophic, 3-whorled, smooth, light colored; shoulder of early teleoconch whorls coronated, coronations lost by 3rd to 6th teleoconch whorl; early juvenile shells with 2-3 in-

cised spiral striae below the shoulder. Color dark yellow to orange brown, with two irregular, often interrupted white bands; basal area variegated with white; white mottling at the shoulder produces light and dark radial markings on spire; ground color on spire of greater intensity than that of body whorl; aperture white within. Periostracum brownish, thin over body whorl, thicker on spire and produced in closely set, thin, arched ridges. Operculum bluntly unguiculate, about two times longer than wide.

Radula (Figure 3): Tooth of the "*Conus regularis* type" (NYBAKKEN, 1970), with single barb at the tip, a well-developed opposite blade extending about 1/3 the length of the tooth; serration prominent and extending about the same distance as the blade; waist slight; base enlarged with a small spur on one side.



Figure 3

C. xanthicus, from 35.7 mm specimen (shell, Figure 21).
Radular tooth (scale = 0.1 mm)

Radula preparations were made from ten specimens, ranging in shell length from 14.2-54.3 mm, including those illustrated in Figures 13 (holotype), 15, 18, 19, 21, and 23. There was no significant variation in tooth morphology among the examined specimens.

Distribution and occurrence: Morro Colorado, Sonora, Mexico (type locality of *Conus chrysocestus*), to Rocas Octavia, Colombia (6°47'N; AHF 431-35); Revillagigedo Islands, Mexico, and Galápagos Islands, Ecuador. All oc-

currences are well offshore, chiefly in the 50-140m depth range. We have examined 4 lots from Sonora, 14 lots from the southeastern side of Baja California from Isla Carmen to the Gorda Banks off Cape San Lucas, 12 lots from Isla Clarion, Revillagigedo Islands, 1 lot from southern Mexico, 1 lot from the Perlas Islands, Panama, 1 lot from Colombia (Figure 19) and 10 lots from the Galápagos Islands. The Rocas Octavia locality in Colombia is both the southernmost record known for *C. xanthicus* and the only station from which both *C. xanthicus* and *C. fergusonii* have been collected together.

Comparisons: Although *Conus xanthicus* could not be confused with large, fully mature specimens of *C. fergusonii*, it has been confused with immature specimens of the latter. Mature *C. xanthicus* differ from immature *C. fergusonii* in lacking coronations, producing the suture below (rather than at) the shoulder, having a narrower aperture, having an irregular, mottled (rather than even) banding pattern on the body whorl, and having a mottled (rather than unmarked) pattern on the spire. Juvenile *C. xanthicus* do not have the regular rows of spots of juvenile *C. fergusonii*. *Conus xanthicus* has a general resemblance to *C. virgatus* Reeve, 1849, but has a more angulate shoulder and does not have the axial color markings of that species. Like *C. fergusonii*, *C. virgatus* also produces the suture at the shoulder. Comparisons with *C. kohni* are given under the treatment of that species.

Variability: *Conus xanthicus* is highly variable in breadth and in spire profile. Too few specimens are available to fully document the range of variation, but some generalizations may be made. Those seen from Sonora are relatively low spired, although the spire of the holotype of *C. xanthicus* (Figure 13) is higher than that of the holotype of the synonymous *C. chrysocestus* (Figure 14). Those from the southeastern side of Baja California are similarly

variable, but some higher spired forms are known from the region (Figure 16). Specimens from Isla Clarion are rather small and uniform (Figure 18). The Colombian specimen (Figure 19) is rather narrow and high spired. Galapagan specimens (Figures 20-23) are rather uniformly narrow and moderately high spired.

Remarks: The holotype of *Conus xanthicus* (USNM 111236, Figure 13), from 130m off Guaymas, Sonora, Mexico, was not originally figured. The taxon was apparently not discussed again until HANNA & STRONG (1949) figured the holotypes and placed the name in the synonymy of *C. fergusonii*. The holotype of the synonymous *C. chrysocestus* Berry remains in the private collection of S. Stillman Berry, Redlands, California (Figure 14). It is also from Sonora, Mexico: "trawled in 30 to 45 fms., off Morro Colorado, Sonora; Antonio Luna, Dec. 1965." It is a large, brightly colored specimen which was not compared by Berry to *C. xanthicus*. He apparently did not question the long-held view of other authors concerning the validity of *C. xanthicus*.

Conus kohni McLean & Nybakken, spec. nov.

(Figures 4, 24-29)

Diagnosis: Coronations present only at very early stage, spire whorls markedly concave, aperture relatively broad; color yellow-orange, with mottled, lighter colored banding; spire with radial markings of same intensity as that of rest of shell.

Description: Shell medium-sized (maximum length 52.5 mm, with 9 teleoconch whorls); spire moderately elevated; spire outline slightly concave to straight; shoulder distinctly ridged, not coronated in mature specimens; spire whorls

Explanation of Figures 24 to 29

Conus kohni McLean & Nybakken, spec. nov.

- Figure 24: LACM 1885, holotype, 18-37 m, Isla Isabela, Galápagos Islands, Ecuador. Radula verified specimen, length 35.3 mm, periostracum removed ventrally, intact on spire.
- Figure 25: AHF 788-38, 101 m, coral & shell bottom, off Isla Daphne, Galápagos Islands, Ecuador. Length 52.3 mm, periostracum removed, lip broken back (largest specimen examined).
- Figure 26: AHF 788-38, same locality as Figure 25. Length 43.5 mm, periostracum intact.
- Figure 27: LACM 72-200, 40-45 m, coralline algal rubble, Bahía Academia, Isla Santa Cruz, Galapagos Islands, Ecuador. Radula verified specimen, length 40.0 mm, periostracum removed.
- Figure 28: CAS 46379, Isla Santa Cruz, Galápagos Islands, Ecuador. Length 33.6 mm, periostracum removed.
- Figure 29: AHF 324-35, 82 m, rock, Caleta Tagus, Isla Isabela, Galápagos Islands, Ecuador. Radula verified specimen, length 15.0 mm, periostracum partially intact (smallest specimen examined).